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NFRC

COMPARISON OF RESULTS FOR 11 FENESTRATION SYSTEMS USING NFRC 100-2002 (WINDOW5/THERM5) vs. NFRC 100-97 (W4.1/THERM2.1a)

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INTRODUCTION

New NFRC 100-2002 standard incorporates numerous modifications and improvements, as detailed in ISO 15099, which is now a basis calculational document for NFRC 100. WINDOW5/THERM5 software has been developed to fully comply with ISO 15099 and is currently approved for use in NFRC rating process. This document presents comparison of results using old (NFRC 100-97) standard, as incorporated in THERM2.1a/WINDOW4.1 software, vs. the new (NFRC 100-2002), as incorporated in THERM5/WINDOW5 software. A range of fenestration products has been chosen for comparison and is given in Table 1. The 11 products, selected for this comparison study, include various NFRC Test and Simulation Round Robin specimens, several commercial fenestration systems, Sample wood and PVC windows, and two skylights.

Table 1: Fenestration Products for Comparison between WINDOW4.1 and WINDOW5

ID	Fenestration System Type	IGU and spacer
1	Thermally broken Aluminum Fixed Window – 2001 NFRC Testing Round Robin, (TRR01)	Low-E-air-HM-air-low-E; Aluminum Spacer
2	Aluminum Horizontal Slider Window – 1999 and 2000 NFRC Testing Round Robin (TRR99)	Clear-air-HM-air-low-E; Steel Spacer
3	Aluminum-Clad Wood Fixed Window – 1997 and 1998 NFRC Round Robin (TRR97)	Low-E-air-Clear; Steel Intercept Spacer
4	PVC casement window	Low-E-air-Clear; TrueSeal Swiggle Strip Spacer
5	Wood fixed window (PFM01 and PFM02) with two types of spacers	PFM01: Clear-air-Clear, PFM02: Clear-air-Low-E; Al. Spacer and Insulating Spacer
6	Thermally-broken Aluminum curtain wall with bolts – 2002 NFRC Simulation Round Robin (SRR02)	Clear-air-clear, Aluminum Spacer
7	Thermally-Broken Aluminum Curtain Wall with Pour-Skip-De-Bridge Thermal Break (CW#1)	Clear-air-clear: Aluminum Spacer
8	Thermally-Broken Aluminum Curtain Wall with Pour-Skip-De-Bridge Thermal Break and Thermal Slot (CW#3)	Clear-air-clear,; Aluminum Spacer
9	Thermally-Improved Aluminum Curtain Wall (CW#4)	Clear-air-clear; Aluminum Spacer
10	Thermally-Broken Aluminum Skylight	Clear-air-lowE, Clear-Ar-Low-E; Aluminum Spacer
11	Aluminum-Clad Wood Skylight	Low-E-Air Clear, Low-E-Argon-Clear; Aluminum Spacer

The parameters selected for comparison include U factor, SHGC, VT, CR and FR. An additional set of calculations has been performed on a sample wood window (PFM01 and PFM02), to see the effect of spacer type and glazing systems variations. The spacers included for comparison are; the original Al spacer and an assumed insulating spacer (k_{eff} = 0.1W/mK).

A brief description and results for different cases have been presented in the following section. The percentage difference in tables is based on WINDOW 5 run (W5) as a base case.

Table A. Impact of Size and Method on Thermal Performance of Different Fenestration Products

Fenestration system	Params	NFRC 100-97 - A	NFRC 100-97 - B	NFRC 100-2002	% Difference	
1-1a) Thermally broken Aluminum (TRR01), Casement [NFRC SLC]	*Size*	*24”x48’’*	*30"x60"*	*24"x59"*	*A*	*B*
	U	0.479	0.432	0.427	-12.18	-1.17
	SHGC	0.272	0.279	0.247	-10.12	-12.96
	VT	0.385	0.413	0.392	1.79	-5.36
1-1b) Thermally broken Aluminum (TRR01), Casement [NFRC Chicago]	*Size*	*24”x48’’*	*30"x60"*	*24"x59"*	*A*	*B*
	U	0.479	0.432	0.436	-9.86	0.92
	SHGC	0.272	0.279	0.248	-9.68	-12.50
	VT	0.385	0.413	0.392	1.79	-5.36
1-2a) Thermally Broken Aluminum (TRR01), Fixed [NFRC SLC]	*Size*	*48”x48’’*	*48"x72"*	*47"x59"*	*A*	*B*
	U	0.398	0.371	0.357	-11.48	-3.92
	SHGC	0.284	0.288	0.269	-5.58	-7.06
	VT	0.433	0.449	0.440	1.59	-2.05
1-2b) Thermally Broken Aluminum (TRR01), Fixed [NFRC Chicago]	*Size*	*48”x48’’*	*48"x72"*	*47"x59"*	*A*	*B*
	U	0.398	0.371	0.372	-6.99	0.27
	SHGC	0.284	0.288	0.278	-2.16	-3.60
	VT	0.433	0.449	0.440	1.59	-2.05
1-3) Thermally broken Aluminum (TRR01), Casement [NFRC Chicago, Valid. Size]	*Size*	*40”x40’’*				
	U	0.430 [Test Result: U=0.41]		0.403	-6.70 [-1.7]	
	SHGC	0.279		0.257	-8.56	
	VT	0.414		0.413	-0.24	
2-1a) Aluminum (TRR99) Horizontal Slider [NFRC SLC]	*Size*	*60”x36”*	*72”x48”*	*59”x47*	*A*	*B*
	U	0.615	0.553	0.481	-27.86	-14.97
	SHGC	0.345	0.344	0.311	-10.93	-10.61
	VT	0.499	0.516	0.508	1.77	-1.57
2-1b) Aluminum (TRR99) Horizontal Slider [NFRC Chicago]	*Size*	*60”x36”*	*72”x48”*	*59”x47*	*A*	*B*
	U	0.615	0.553	0.519	-18.50	-6.55
	SHGC	0.345	0.344	0.313	-10.22	-9.90
	VT	0.499	0.516	0.508	1.77	-1.57
2-2) Aluminum (TRR99) Horizontal Slider [NFRC Chicago, Valid. Size]	*Size*	*60”x36’’*				
	U	0.615 [Test Result: U=0.57]		0.546	-12.64 [-4.2%]	
	SHGC	0.345		0.309	-11.65	
	VT	0.499		0.499	0.00	
3-1a) Aluminum-Clad Wood (TRR97), Casement [NFRC SLC]	*Size*	*24"x48”*	*30”x60”*	*24"x59*	*A*	*B*
	U	0.374	0.360	0.353	-5.95	-1.98
	SHGC	0.328	0.342	0.321	-2.18	-6.54
	VT	0.543	0.575	0.553	1.81	-3.98
3-1b) Aluminum-Clad Wood (TRR97), Casement [NFRC Chicago]	*Size*	*24"x48”*	*30”x60”*	*24"x59*	*A*	*B*
	U	0.374	0.360	0.353	-5.95	-1.98
	SHGC	0.328	0.342	0.321	-2.18	-6.54
	VT	0.543	0.575	0.553	1.81	-3.98

Fenestration system	Params	NFRC 100-97 - A	NFRC 100-97 - B	NFRC100-2002	% Difference	
3-2a) Aluminum-Clad Wood (TRR97), Fixed [NFRC SLC]	*Size*	*48"x48"*	*48"x72"*	*47"x59*	*A*	*B*
	U	0.350	0.343	0.335	-4.48	-2.39
	SHGC	0.352	0.360	0.349	-0.86	-3.15
	VT	0.596	0.614	0.606	1.65	-1.32
3-2b) Aluminum-Clad Wood (TRR97), Fixed [NFRC Chicago]	*Size*	*48"x48"*	*48"x72"*	*47"x59*	*A*	*B*
	U	0.350	0.343	0.335	-4.48	-2.39
	SHGC	0.352	0.360	0.349	-0.86	-3.15
	VT	0.596	0.614	0.606	1.65	-1.32
3-3) Thermally broken Aluminum (TRR97), Casement [NFRC Chicago, Valid. Size]	*Size*	*48"x48''*				
	U	0.350 [Test Result: U=0.33]		0.339	-3.24 [2.7%]	
	SHGC	0.352		0.345	-2.03	
	VT	0.596		0.597	0.17	
4-1a) PVC window, Casement [NFRC SLC]	*Size*	*24"x48''*	*30"x60"*	*24"x59"*	*A*	*B*
	U	0.312	0.310	0.312	0	0.64
	SHGC	0.266	0.290	0.264	-0.76	-9.85
	VT	0.384	0.426	0.394	2.54	-8.12
4-1b) PVC window, Casement [NFRC Chicago]	*Size*	*24"x48''*	*30"x60"*	*24"x59"*	*A*	*B*
	U	0.312	0.310	0.312	0	0.64
	SHGC	0.266	0.290	0.264	-0.76	-9.85
	VT	0.384	0.426	0.394	2.54	-8.12
4-2a) PVC window, Fixed [NFRC SLC]	*Size*	*48"x48''*	*48"x72"*	*47"x59"*	*A*	*B*
	U	0.310	0.308	0.308	-0.65	0
	SHGC	0.310	0.322	0.313	0.96	-2.88
	VT	0.463	0.483	0.473	2.11	-2.11
4-2b) PVC window, Fixed [NFRC Chicago]	*Size*	*48"x48''*	*48"x72"*	*47"x59"*	*A*	*B*
	U	0.310	0.308	0.307	-0.98	-0.33
	SHGC	0.310	0.322	0.313	0.96	-2.88
	VT	0.463	0.483	0.473	2.11	-2.11
4-3) PVC window, Casement [NFRC Chicago, Valid. Size]	*Size*	*24"x48''*				
	U	0.312 [Test Result: U=0.31]		0.313	0.32 [1.0%]	
	SHGC	0.266		0.258	-3.10	
	VT	0.384		0.384	0	
5a-1a Wood Window (PFM01), Casement [NFRC SLC]	*Size*	*24"x48''*	*30"x60"*	*24"x59"*	*A*	*B*
	U	0.498	0.496	0.472	-5.51	-5.08
	SHGC	0.600	0.625	0.604	0.66	-3.48
	VT	0.646	0.677	0.656	1.52	-3.20
5a-1b) Wood Window (PFM01), Casement [NFRC Chicago]	*Size*	*24"x48''*	*30"x60"*	*24"x59"*	*A*	*B*
	U	0.498	0.496	0.470	-5.96	-5.53
	SHGC	0.600	0.625	0.604	0.66	-3.48
	VT	0.646	0.677	0.656	1.52	-3.20

Fenestration system	Params	NFRC 100-97 - A	NFRC 100-97 - B	NFRC100-2002	% Difference	
5a-2a) Wood Window (PFM01), Fixed [NFRC SLC]	*Size*	*48”x48’’*	*48"x72"*	*47"x59"*	*A*	*B*
	U	0.494	0.493	0.471	-4.88	-4.67
	SHGC	0.642	0.657	0.651	1.38	-0.92
	VT	0.699	0.716	0.709	1.41	-0.99
5a-2b) Wood Window (PFM01), Fixed [NFRC Chicago]	*Size*	*48”x48’’*	*48"x72"*	*47"x59"*	*A*	*B*
	U	0.494	0.493	0.470	-5.11	-4.89
	SHGC	0.642	0.657	0.651	1.38	-0.92
	VT	0.699	0.716	0.709	1.41	-0.99
5a-3) Wood Window (PFM01), Casement [NFRC Chicago, Valid. Size]	*Size*	*24”x36’’*				
	U	0.499 [Test Result: U=??]		0.474	-5.27 [??%]	
	SHGC	0.586		0.582	-0.69	
	VT	0.630		0.630	0	
5b-1a) Wood Window (PFM02), Casement [NFRC SLC]	*Size*	*24”x48’’*	*30"x60"*	*24"x59"*	*A*	*B*
	U	0.335	0.333	0.359	6.69	7.24
	SHGC	0.280	0.290	0.280	0	-3.57
	VT	0.320	0.340	0.360	11.11	5.56
5b-1b) Wood Window (PFM02), Casement [NFRC Chicago]	*Size*	*24”x48’’*	*30"x60"*	*24"x59"*	*A*	*B*
	U	0.335	0.333	0.359	6.69	7.24
	SHGC	0.280	0.290	0.280	0	-3.57
	VT	0.320	0.340	0.360	11.11	5.56
5b-2a) Wood Window (PFM02), Fixed [NFRC SLC]	*Size*	*48”x48’’*	*48"x72"*	*47"x59"*	*A*	*B*
	U	0.358	0.352	0.346	-3.47	-1.73
	SHGC	0.299	0.305	0.301	0.66	-1.33
	VT	0.383	0.392	0.389	1.54	-0.77
5b-2b) Wood Window (PFM02), Fixed [NFRC Chicago]	*Size*	*48”x48’’*	*48"x72"*	*47"x59"*	*A*	*B*
	U	0.358	0.352	0.345	-3.77	-2.03
	SHGC	0.299	0.305	0.301	0.66	-1.33
	VT	0.383	0.392	0.389	1.54	-0.77
5b-3) Wood Window (PFM02), Casement [NFRC Chicago, Valid. Size]	*Size*	*24”x36’’*				
	U	0.380 [Test Result: U=??]		0.365	-4.11 [??%]	
	SHGC	0.276		0.271	-1.85	
	VT	0.345		0.346	0.29	
6) Curtain Wall with Bolt (SRR02) [NFRC SLC]	*Size*	*80”x80”*	*80”x80”*	*79”x79*	*A*	*B*
	U	0.589	0.589	0.573	-2.8	-2.8
	SHGC	0.612	0.612	0.605	-1.2	-1.2
	VT	0.657	0.657	0.658	0.2	0.2
7) Curtain Wall with Pour–De-Bridge Thermal Break (CW#1) [NFRC SLC]	*Size*	*80”x80”*	*80”x80”*	*79”x79*	*A*	*B*
	U	0.617	0.617	0.594	-3.9	-3.9
	SHGC	0.620	0.620	0.611	-1.5	-1.5
	VT	0.662	0.662	0.662	0	0

8) Curtain Wall with Skip–De-Bridge Thermal Break and Thermal Slot (CW#3) [NFRC SLC]	*Size*	*80”x80”*	*80”x80”*	*79”x79*	*A*	*B*
	U	0.567	0.567	0.546	-3.8	-3.8
	SHGC	0.62	0.62	0.611	-1.5	-1.5
	VT	0.67	0.67	0.674	~	~
9) Thermally Improved Curtain Wall (CW#4) [NFRC SLC]	*Size*	*80”x80”*	*80”x80”*	*79”x79*	*A*	*B*
	U	0.573	0.573	0.541	-5.9	-5.9
	SHGC	0.625	0.625	0.617	-1.3	-1.3
	VT	0.677	0.677	0.677	0	0
10) Thermally-broken Aluminum skylight [NFRC SLC]	*Size*	48”x48” (46.5x46.5)	48”x48” (46.5x46.5)	47”x47” (45.5x45.5)	*A*	*B*
	U	0.541	0.541	0.632	14.4	14.4
	SHGC	0.617	0.617	0.586	-5.3	-5.3
	VT	0.708	0.708	0.708	0	0
11) Aluminum clad wood skylight [NFRC SLC]	*Size*	48”x48” (46.5x46.5)	48”x48” (46.5x46.5)	47”x47” (45.5x45.5)	*A*	*B*
	U	0.400	0.400	0.497	19.5	19.5
	SHGC	0.339	0.339	0.323	-4.9	-4.9
	VT	0.600	0.600	0.599	-0.2	-0.2

Notes: NFRC 100-97 sizes A and B are calculated by T21a/W41 and NFRC 100-2002 are calculated by T5/W5

% Difference A and B are percentage differences between NFRC 100-2002 and NFRC 100-1997 sizes A and B, respectively (% Difference for Round Robins is for single size between NFRC 100-2002 and NFRC 100-1997.

[ ] indicates test result and percentage difference between NFRC 100-2002 and test result, when indicated in % Difference column.

**: The values for skylights calculated with W41/T21a are for vertical orientation, while W5/T5 are for sloped (20º).

Case 1: Thermally-broken Aluminum, Fixed Window - 2001 NFRC Testing Round Robin (TRR01)

This fixed casement window (40”x40”) was selected as a specimen for 2001 NFRC Testing Round Robin (known as TRR01). It consists of a triple-glazed, fixed, low-E glazing with heat mirror. The schematic representation of the material locations for a sill section is shown in Fig. 1. The glazing unit is a 3 layered unit with AFG low-E as the 1st and the 3rd layer, and Heat Mirror SC75 as a 2nd layer. Surface 2, 4 and 5 are low-E (e2=0.204, e4=0.052 and e5=0,204) surfaces. The filled gas is air, 0.338 inches for each gap. The overall thickness of this glazing unit is 0.92 inch. Table 1 shows the comparison of results between old NFRC method (WINDOW 4.1 / THERM 2.1a) and new NFRC method (WINDOW 5 / THERM 5)

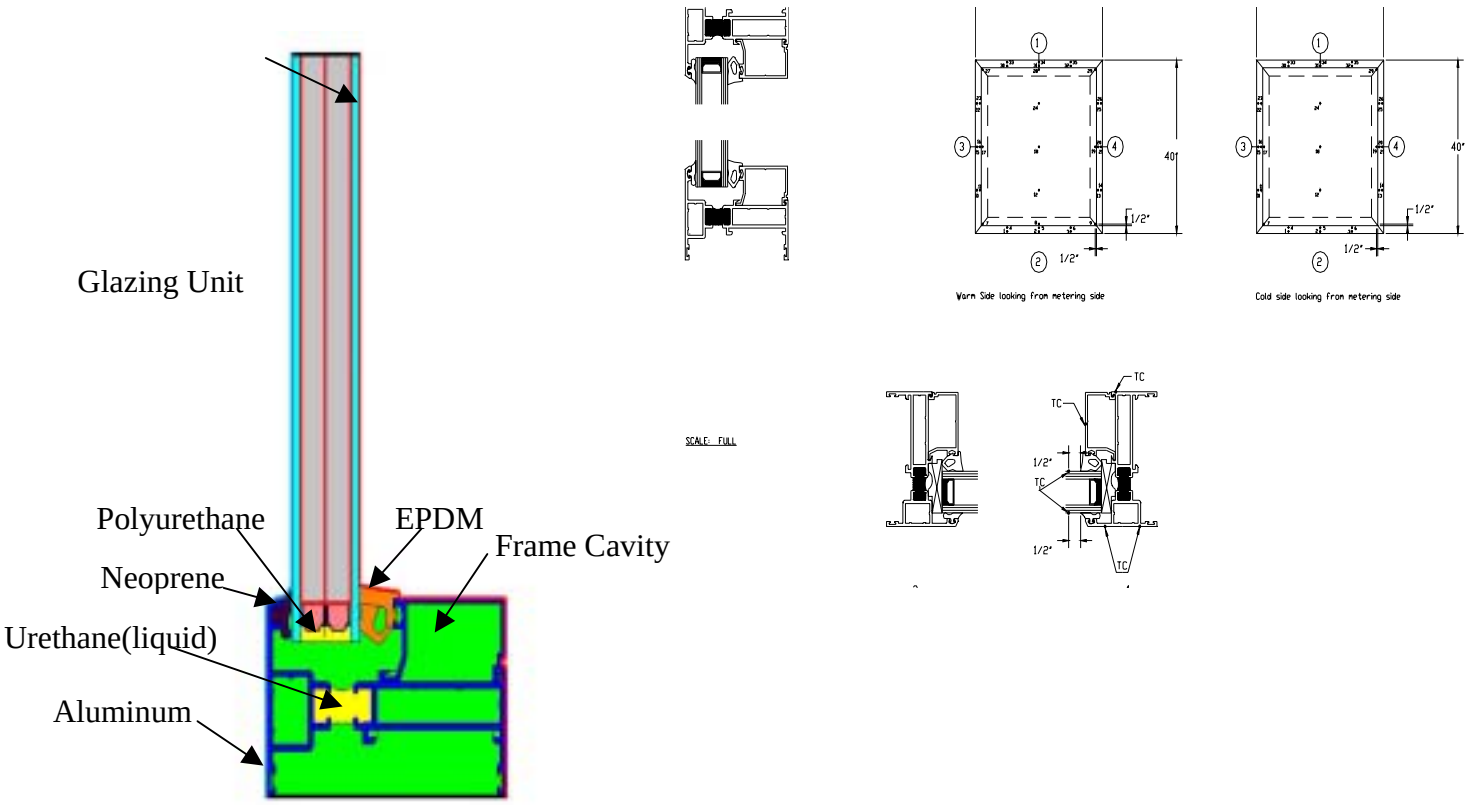

Figure 1. Drawings and List of Materials for Thermally-Broken Aluminum, Fixed Window (TRR01)

Table 1a: Simulation Results for Thermally-broken Aluminum, Fixed Window - 2001 NFRC Testing Round Robin (TRR01)

U factor (Btu/h-ft^2-F)	TRR 01				Experimental
	W4_Therm2		W5_Therm5		
	Frame	Edge	Frame	Edge	
Head	1.0408	0.3254	0.9141	0.2885	
Sill	1.0408	0.3254	0.9134	0.2875	
Jamb	1.0408	0.3254	0.9462	0.2876	
Overall Ufactor	0.430		0.396 [-3.41%]		0.41
% Difference	-8.59 %				
Overall SHGC	0.279		0.251 (0.257)*		
% Difference	-7.31 % (-8.56%)*				
Overall VT	0.414		0.413		
% Difference	~				
U factor U_{cog}	0.225		0.222		
% Difference	-1.35%				
$SHGC_{cog}$	0.31		0.312		
% Difference	~				
VT_{cog}	0.53		0.534		
% Difference	~				
FR_{cog}	N/A				
% Difference	N/A				
CI_f	41.85		41.33		
CI_g	76.80		74.16		
CI_{eog}	59.23		56.38		
CI	42		41		
Difference	-1				

Note: * SHGC calculated using exterior tag (exterior developed surface area)

Table 1b: Simulation Results for Thermally-broken Aluminum, Fixed Window - 2001 NFRC Testing Round Robin (TRR01) w/o the Use of Partially Ventilated Cavities and with Separate Frame Convective Film Coefficient

U factor ($Btu/h\text{-}ft^2\text{-}F$)	TRR 01				Experimental
	W4_Therm2		W5_Therm5		
	Frame	Edge	Frame	Edge	
Head	1.0408	0.3254	0.952	0.280	
Sill	1.0408	0.3254	0.952	0.280	
Jamb	1.0408	0.3254	0.987	0.280	
Overall U-factor	0.430 [4.90 %]		0.403 [-1.71%]		0.41
% Difference	-8.59 %				
Overall SHGC	0.279		0.258*		
% Difference	-3.70%				
Overall VT	0.414		0.413		
% Difference	~				
U factor U_{cog}	0.225		0.222		
% Difference	-1.35%				
$SHGC_{cog}$	0.31		0.312		
% Difference	~				
VT_{cog}	0.53		0.534		
% Difference	~				
FR_{cog}	N/A				
% Difference	N/A				
CI_f	41.85		43.04		
CI_g	76.80		74.16		
CI_{eog}	59.23		57.76		
CI	42		43		
Difference	1				

Note: * SHGC calculated using exterior tag (exterior developed surface area)

Case 2: Aluminum Horizontal Slider Window –1999 and 2000 NFRC Testing Round Robin (TRR99)

This window represents specimen for 1999 and 200 NFRC Testing Round Robins. It is a nominal 60’’x36” Aluminum horizontal slider window. The schematic representation of the material locations for a sill section is shown in Figure 2. The glazing unit consists of two panes of 0.129" sheets of PPG glass separated by a 0.003” thick heat mirror with coating on the inner side (ε=0.088) and two air spaces each of 0.244”. The outer surface of inner glass has low-E coating (ε=0.088). Table 2 shows the comparison of results between old NFRC method (WINDOW 4.1 / THERM 2.1a) and new NFRC method (WINDOW 5 / THERM 5).

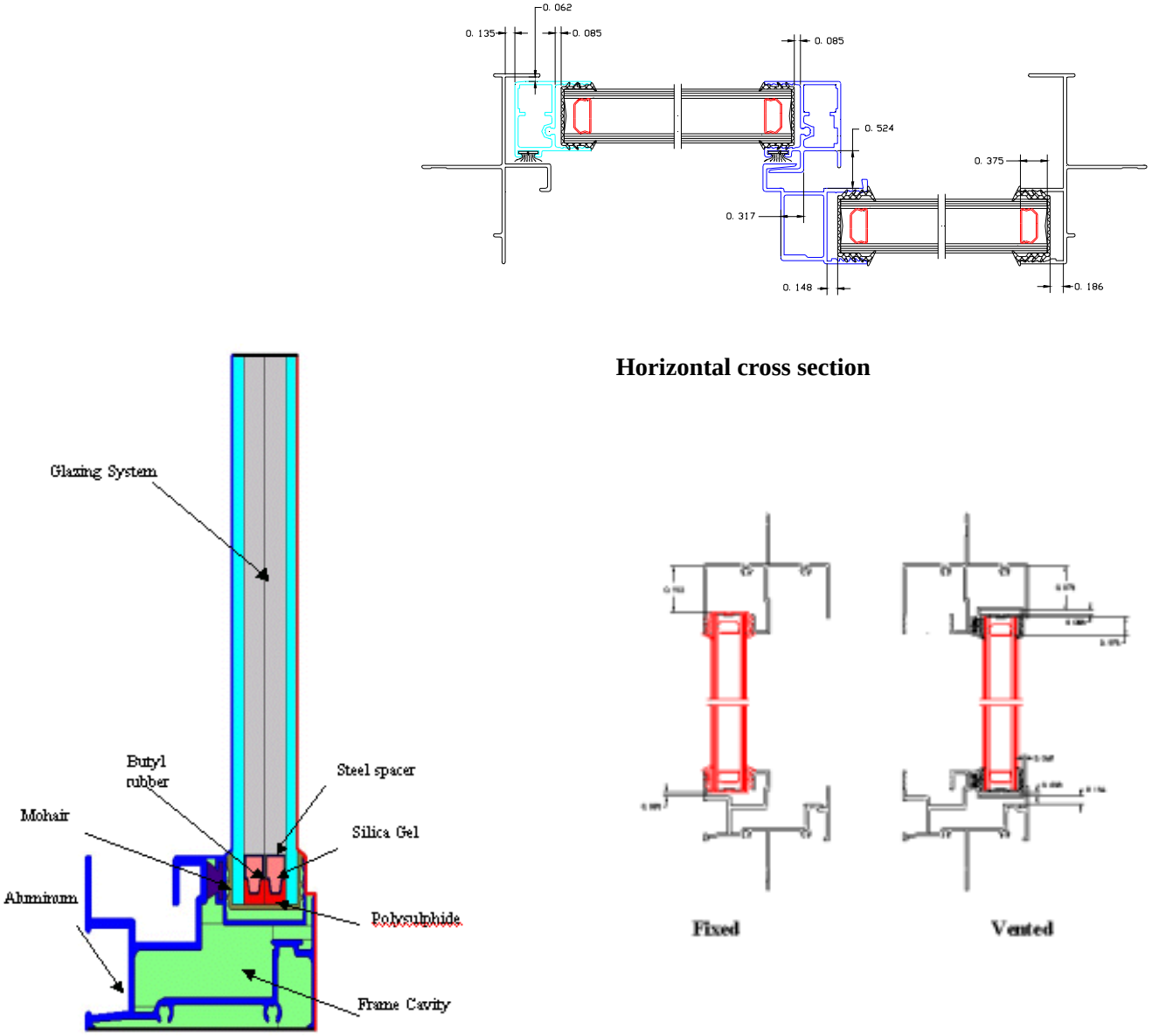

Figure 2. Drawings and List of Materials for Aluminum Horizontal Slider Window (TRR99)

Table 2: Simulation Results for Aluminum Horizontal Slider Window – 1999 and 2000 NFRC Testing Round Robin (TRR99)

U-factor	W4_Therm2		W5_Therm5		Experimental
	Frame	Edge	Frame	Edge	
Fixed Head	2.455	0.386	1.779	0.364	
Fixed Sill	3.635	0.408	2.054	0.383	
Fixed Jamb	2.674	0.387	2.158	0.354	
MR	2.822	0.413	1.495	0.412	
Vented Head	1.382	0.469	1.131	0.449	
Vented Sill	1.374	0.470	1.113	0.446	
Vented Jamb	1.345	0.468	1.106	0.449	
Overall U	0.615		0.505 [-9.82%]		0.56
% Difference	-21.18%				
Overall SHGC	0.345		0.306 (0.307)*		
% Difference	-11.11%				
Overall VT	0.499		0.499		
% Difference	~				
U factor U_{cog}	0.315		0.309		
% Difference	-1.94%				
$SHGC_{cog}$	0.34		0.346		
% Difference	~				
VT_{cog}	0.58		0.581		
% Difference	~				
FR_{cog}	N/A		N/A (?)		
% Difference	N/A				
CI_f	16.62		14.83		
CI_g	66.67		65.09		
CI_{eog}	51.16		44.64		
CI*	17		15		
Difference	-2				

Table 2a: Simulation Results for Aluminum Horizontal Slider Window – 1999 and 2000 NFRC Testing Round Robin (TRR99) w/o the Use of Partially Ventilated Cavities

U-factor	W4_Therm2		W5_Therm5		Experimental
	Frame	Edge	Frame	Edge	
Fixed Head	2.455	0.386	1.806	0.331	
Fixed Sill	3.635	0.408	2.384	0.379	
Fixed Jamb	2.674	0.387	2.158	0.354	
MR	2.822	0.413	1.983	0.403	
Vented Head	1.382	0.469	1.130	0.447	
Vented Sill	1.374	0.470	1.119	0.447	
Vented Jamb	1.345	0.468	1.106	0.449	
Overall U	0.615 [9.82%]		0.522 [-6.79%]		0.56
% Difference	-17.82%				
Overall SHGC	0.345		0.314		
% Difference	-9.87%				
Overall VT	0.499		0.499		
% Difference	~				
U factor U_{cog}	0.315		0.309		
% Difference	-1.94%				
$SHGC_{cog}$	0.34		0.346		
% Difference	~				
VT_{cog}	0.58		0.581		
% Difference	~				
FR_{cog}	N/A		N/A (?)		
% Difference	N/A				
CI_f	16.62		15.44		
CI_g	66.67		65.09		
CI_{eog}	51.16		47.15		
CI*	17		15		
% Difference	-2				

Note: * SHGC calculated using exterior tag (exterior developed surface area)

Table 2b: Simulation Results for Aluminum Horizontal Slider Window – 1999 and 2000 NFRC Testing Round Robin (TRR99) w/o the Use of Partially Ventilated Cavities and with Separate Frame Convective Film Coefficient

U-factor	W4_Therm2		W5_Therm5		Experimental
	Frame	Edge	Frame	Edge	
Fixed Head	2.455	0.386	1.973	0.330	
Fixed Sill	3.635	0.408	2.669	0.374	
Fixed Jamb	2.674	0.387	2.289	0.350	
MR	2.822	0.413	2.226	0.398	
Vented Head	1.382	0.469	1.244	0.445	
Vented Sill	1.374	0.470	1.230	0.445	
Vented Jamb	1.345	0.468	1.216	0.446	
Overall U	0.615 [9.82%]		0.546 [-2.5%]		0.56
% Difference	-17.82%				
Overall SHGC	0.345		0.309		
% Difference	-8.83%				
Overall VT	0.499		0.499		
% Difference	~				
U factor U_{cog}	0.315		0.309		
% Difference	-1.94%				
$SHGC_{cog}$	0.34		0.346		
% Difference	~				
VT_{cog}	0.58		0.581		
% Difference	~				
FR_{cog}	N/A		N/A (?)		
% Difference	N/A				
CI_f	16.62		16.95		
CI_g	66.67		65.09		
CI_{eog}	51.16		47.80		
CI*	17		17		
Difference	~				

Case 3: Aluminum-Clad Wood Fixed Window – 1997 and 1998 NFRC Testing Round Robin (TRR97)

This window represents the specimen for 1997 and 1998 NFRC testing Round Robin (TRR 97). It is a nominal 48”x48” Aluminum-clad wood fixed window with high performance glazing. The schematic representation of the material locations for a sill section is shown in Figure 3. The glazing was dual-glazed, consisting of nominal 1" thick insulating glazing system fabricated from two 3/16" sheets of glass, 5/8" air space, no inert gas fill and a reported 0.04 emittance Low-E coating at surface 2. The spacer was specified to be a dual-sealed, U-shaped rolled spacer system (Intercept). Table 3 shows the comparison of results between old NFRC method (WINDOW 4.1 / THERM 2.1a) and new NFRC method (WINDOW 5 / THERM 5).

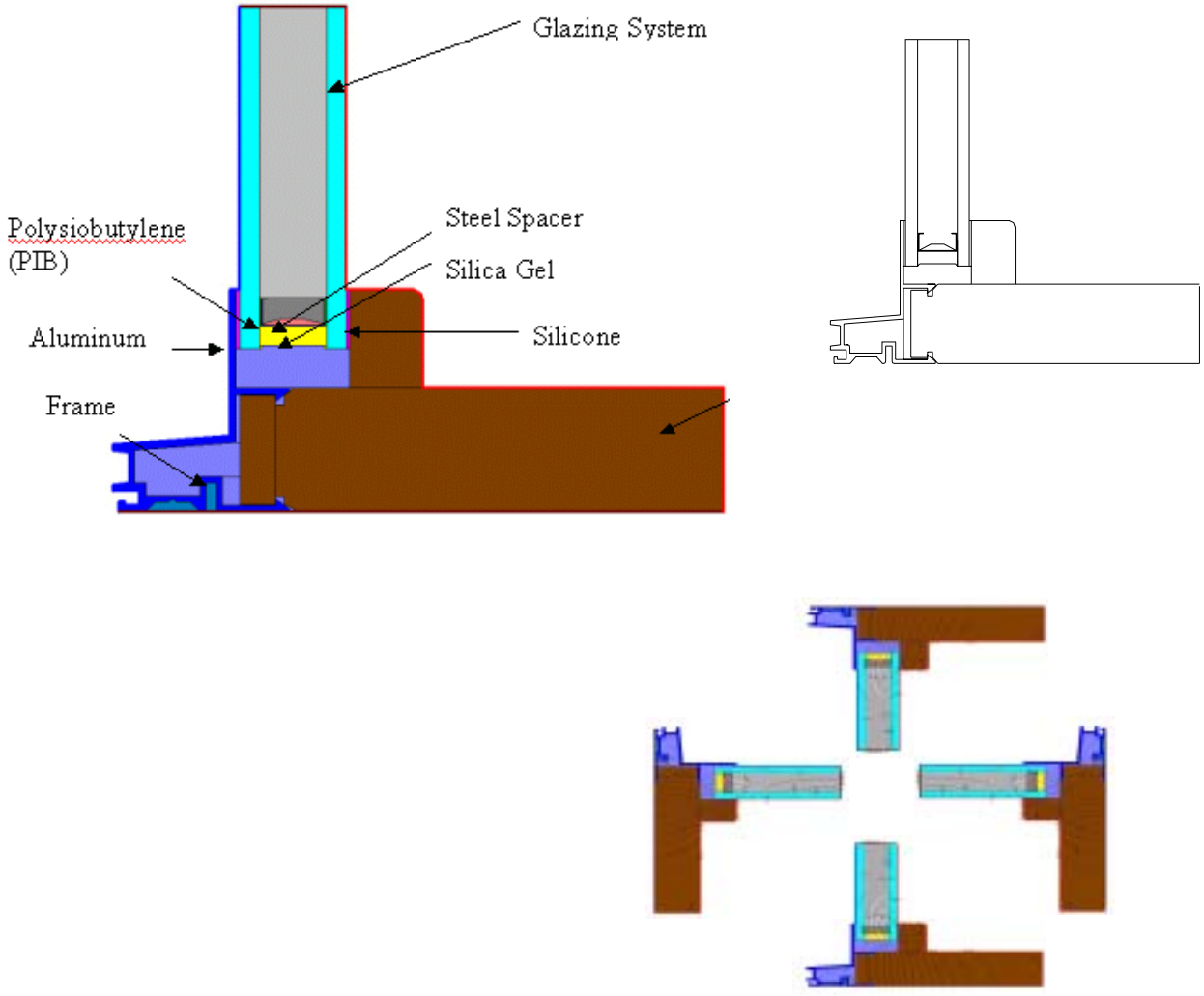

Figure 3. Drawings and List of Materials for Aluminum-Clad Wood Fixed Window (TRR97)

Table 3: Simulation Results for Aluminum-Clad Wood Fixed Window – 1997 and 1998 NFRC Testing Round Robin (TRR97)

U factor ($Btu/h\text{-}ft^2\text{-}F$)	TRR97				Experimental
	W4_Therm2		W5_Therm5		
	Frame	Edge	Frame	Edge	
Head	0.4731	0.4314	0.4293	0.3968	
Sill	0.4731	0.4314	0.4291	0.3965	
Jamb	0.4731	0.4314	0.4330	0.3975	
Overall Ufactor	0.350		0.339 [2.73%]		0.33
% Difference	-3.25 %				
Overall SHGC	0.352		0.345*		
% Difference	-2.03 %				
Overall VT	0.596		0.597		
% Difference	-0.17 %				
U factor U_{cog}	0.300		0.302		
% Difference	0.66 %				
$SHGC_{cog}$	0.40		0.405		
% Difference	1.23 %				
VT_{cog}	0.71		0.708		
% Difference	-0.28 %				
FR_{cog}	N/A		0.322		
% Difference	N/A				
CI_f	65.45		66.37		
CI_g	67.94		65.62		
CI_{eog}	48.73		48.96		
CI	49		49		
% Difference	~				

Note: * SHGC calculated using exterior tag (exterior developed surface area)

Table 3a: Simulation Results for Aluminum-Clad Wood Fixed Window – 1997 and 1998 NFRC Testing Round Robin (TRR97) w/o the Use of Partially Ventilated Cavities and with Separate Frame Convective Film Coefficient

U factor (Btu/h-ft^2-F)	TRR97				Experimental
	W4_Therm2		W5_Therm5		
	Frame	Edge	Frame	Edge	
Head	0.4731	0.4314	0.426	0.396	
Sill	0.4731	0.4314	0.427	0.396	
Jamb	0.4731	0.4314	0.433	0.397	
Overall Ufactor	0.350		0.339 [2.73%]		0.33
% Difference	-3.25 %				
Overall SHGC	0.352		0.347*		
% Difference	-1.44 %				
Overall VT	0.596		0.597		
% Difference	-0.17 %				
U factor U_{cog}	0.300		0.302		
% Difference	0.66 %				
$SHGC_{cog}$	0.40		0.405		
% Difference	1.23 %				
VT_{cog}	0.71		0.708		
% Difference	-0.28 %				
FR_{cog}	N/A		0.322		
% Difference	N/A				
CI_f	65.45		66.31		
CI_g	67.94		65.62		
CI_{eog}	48.73		48.97		
CI	49		49		
% Difference	~				

Note: * SHGC calculated using exterior tag (exterior developed surface area)

Case 4: PVC Casement Window

This window is a nominal 2’ wide by 4’ high PVC casement window by Anlin Industries, which was tested in a hot-box chamber by ATI Lab. Test reports a standard U-factor of 0.31 Btu/h-ft^2-F. The schematic representation of the material locations for a head section is shown in Figure 4. The glazing was double-glazed, consisting of nominal 0.875" thick insulating glazing system fabricated from two 0.125" sheets of glass with a 0.036 emittance Low-E coating at surface 2, and 0.650" air space. Table 4 shows the comparison of results between old NFRC method (WINDOW 4.1 / THERM 2.1a) and new NFRC method (WINDOW 5 / THERM 5).

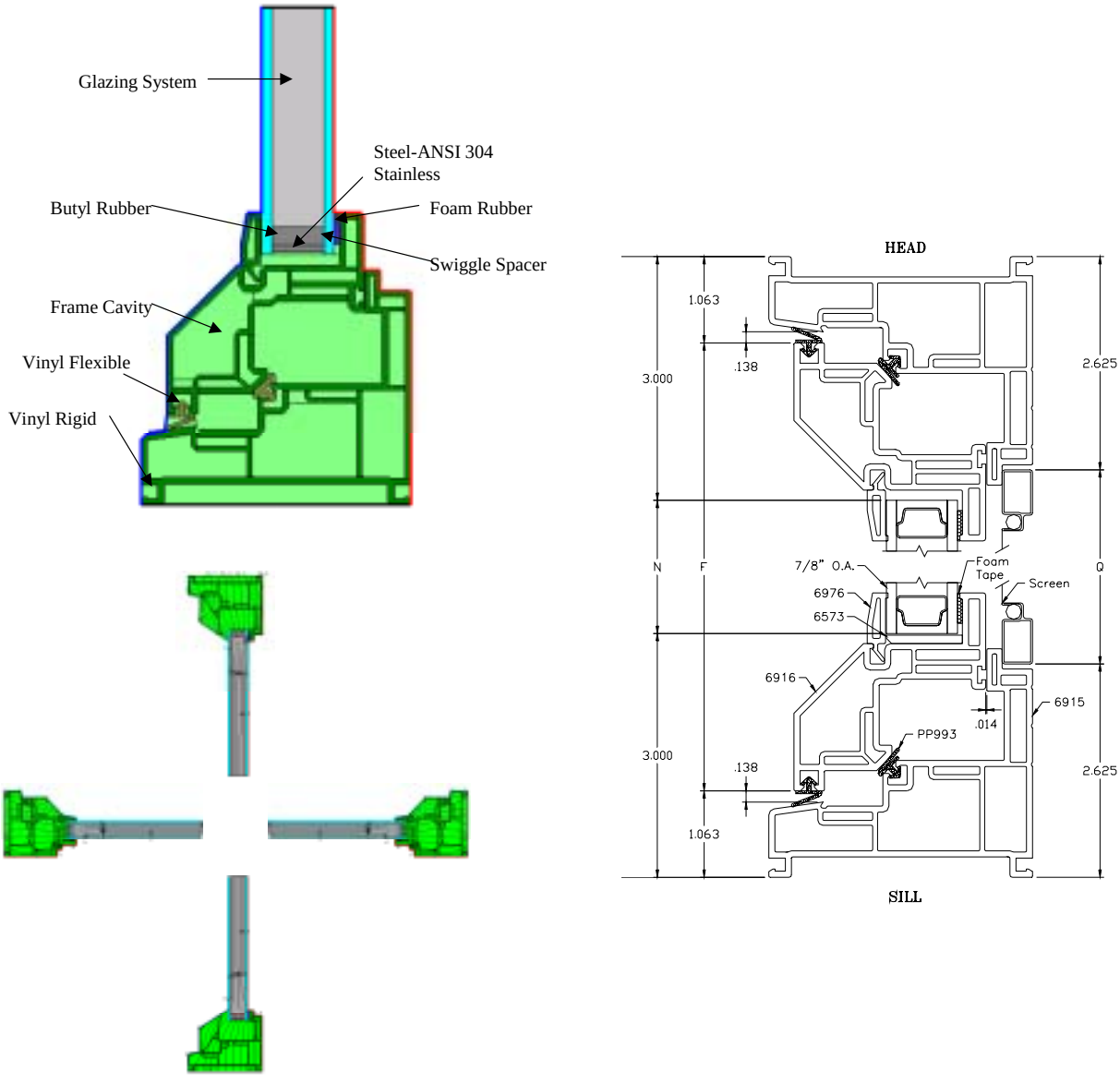

Figure 4. Drawings and List of Materials for a PVC Casement Window

Table 4: Simulation Results of PVC Casement Window

U factor ($Btu/h\text{-}ft^2\text{-}F$)					
	W4_Therm2		W5_Therm5		Experimental
	Frame	Edge	Frame	Edge	
Head	0.3143	0.3579	0.2975	0.3487	
Sill	0.3141	0.3579	0.2929	0.3438	
Jamb	0.2912	0.3558	0.3075	0.3465	
Overall Ufactor	0.312		0.313		0.31
% Difference	0.32 %				
Overall SHGC	0.266		0.263*		
% Difference	-1.14 %				
Overall VT	0.384		0.384		
% Difference	~				
U factor U_{cog}	0.300		0.303		
% Difference	0.99 %				
$SHGC_{cog}$	0.400		0.401		
% Difference	0.25 %				
VT_{cog}	0.610		0.614		
% Difference	0.65 %				
FR_{cog}	N/A		N/A		
% Difference	N/A				
CI_f	70.74		69.86		
CI_g	67.94		65.58		
CI_{eog}	59.13		58.44		
CI	59		58		
Difference	-1				

Note: * SHGC calculated using exterior tag (exterior developed surface area)

Table 4a: Simulation Results of PVC Casement Window) w/o the Use of Partially Ventilated Cavities and with Separate Frame Convective Film Coefficient

U factor ($Btu/h\text{-}ft^2\text{-}F$)					
	W4_Therm2		W5_Therm5		Experimental
	Frame	Edge	Frame	Edge	
Head	0.3143	0.3579	0.2917	0.3440	
Sill	0.3141	0.3579	0.2918	0.3441	
Jamb	0.2912	0.3558	0.3071	0.3473	
Overall Ufactor	0.312		0.313		0.31
% Difference	0.32%				
Overall SHGC	0.266		0.258		
% Difference	-3.10%				
Overall VT	0.384		0.384		
% Difference	~				
U factor U_{cog}	0.300		0.303		
% Difference	0.99 %				
$SHGC_{cog}$	0.400		0.401		
% Difference	0.25 %				
VT_{cog}	0.610		0.614		
% Difference	0.65 %				
FR_{cog}	N/A		N/A		
% Difference	N/A				
CI_f	70.74		69.35		
CI_g	67.94		65.58		
CI_{eog}	59.13		58.31		
CI	59		58		
Difference	-1				

Case 5: Wood Fixed Window (PFM)

This case is a 24”x36” wood fixed window, used as a sample window for THERM program. The schematic representation of the material locations for a sill section is shown in Figure 5. There are two glazing options; PFM01: double-glazed IGU consisting of 1.024" thick insulating glazing system fabricated from clear 0.187" sheets of glass and 0.650" air space, and PFM02: double-glazed IGU consisting of two 0.187" sheets of glass, one clear and one low-e with emissivity of 0.102 and 0.650" air space. In addition, two spacer variations were introduced for each window. Therefore, the following four cases have been considered:

Case a: Clear-clear glazing with Al spacer (PFM01)
Case b: Clear-clear glazing with insulating spacer (PFM01 with spacer k_{eff}=0.1W/mK)
Case c: Clear-lowE glazing (e=0.102 at surface 2) with Al spacer (PFM02)
Case d: Clear-lowE glazing (e=0.102 at surface 2) with insulating spacer (PFM02 with spacer k_{eff}=0.1W/mK)

Tables 5a and 5b shows the comparison of results between old NFRC method (WINDOW 4.1 / THERM 2.1a) and new NFRC method (WINDOW 5 / THERM 5).

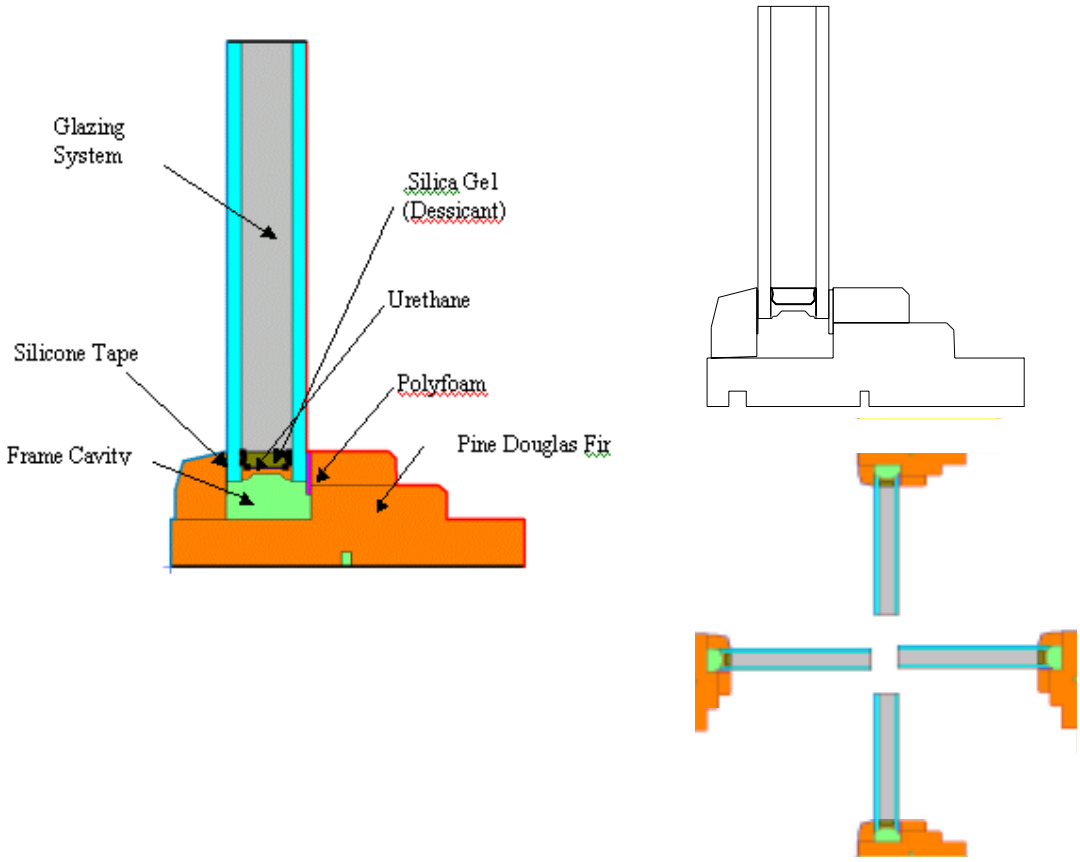

Figure 5a. Drawings and List of Materials for a Wood Fixed Window (PFM01 and PFM02)

Table 5a: Simulation Results for the Wood Fixed Window PFM01

U factor ($Btu/h\text{-}ft^2\text{-}F$)	Clear-clear glazing with Al spacer				Clear-clear glazing with super spacer			
	W4_Therm2		W5_Therm5		W4_Therm2		W5_Therm5	
	Frame	Edge	Frame	Edge	Frame	Edge	Frame	Edge
Head	0.4411	0.5699	0.402	0.5250	0.3512	0.5035	0.3263	0.4742
Sill	0.4411	0.5699	0.405	0.525	0.3512	0.5035	0.3263	0.4742
Jamb	0.4411	0.5699	0.408	0.525	0.3512	0.5035	0.3307	0.4753
Overall	0.499		0.475		0.460		0.444	
% Difference	-5.05%				-3.6%			
Overall SHGC	0.586		0.582		0.583		0.581	
% Difference	-0.68%				-0.34%			
Overall VT	0.63		0.63		0.63		0.63	
% Difference	0%				0%			
U factor C_{cog}	0.485		0.478		0.485		0.478	
% Difference	-1.46%				-1.46%			
SHGCcog	0.73		0.741		0.73		0.741	
% Difference	1.48%				1.48%			
VTcog	0.81		0.809		0.81		0.809	
% Difference	-0.12%				-0.12%			
FR	N/A		0.561		N/A		0.809	
% Difference	N/A				N/A			
CI_f	68.92		67.96		73.53		74.18	
CI_g	50.91		48.42		50.91		48.42	
CI_{eog}	43.74		40.21		48.90		45.49	
CI	44		40		49		45	
Difference	-4				-4			

Table 5a1: Simulation Results for the Wood Fixed Window PFM01) w/o the Use of Partially Ventilated Cavities and with Separate Frame Convective Film Coefficient

U factor ($Btu/h\text{-}ft^2\text{-}F$)	Clear-clear glazing with Al spacer			
	W4_Therm2		W5_Therm5	
	Frame	Edge	Frame	Edge
Head	0.4411	0.5699	0.3970	0.5272
Sill	0.4411	0.5699	0.3962	0.5258
Jamb	0.4411	0.5699	0.3989	0.5259
Overall	0.499		0.474	
% Difference	-5.27%			
Overall SHGC	0.586		0.582	
% Difference	-0.68%			
Overall VT	0.630		0.630	
% Difference	0%			
U factor C_{cog}	0.485		0.478	
% Difference	-1.46%			
SHGCcog	0.73		0.741	
% Difference	1.48%			
VTcog	0.81		0.809	
% Difference	-0.12%			
FR	N/A		0.561	
% Difference	N/A			
CI_f	68.92		66.69	
CI_g	50.91		48.42	
CI_{eog}	43.74		39.93	
CI	44		40	
Difference	-4			

Table 5b: Simulation Results for the Wood Fixed Window PFM02

U factor ($Btu/h\text{-}ft^2\text{-}F$)	Clear-lowE glazing with Al spacer				Clear-lowE glazing with super spacer			
	W4_Therm2		W5_Therm5		W4_Therm2		W5_Therm5	
	Frame	Edge	Frame	Edge	Frame	Edge	Frame	Edge
Head	0.4278	0.4474	0.3928	0.4162	0.3305	0.3698	0.3077	0.3529
Sill	0.4278	0.4474	0.3957	0.4175	0.3305	0.3698	0.3077	0.3530
Jamb	0.4278	0.4474	0.3985	0.4176	0.3305	0.3698	0.3121	0.3543
Overall	0.380		0.366		0.336		0.329	
% Difference	-4.1%				-1.8%			
Overall SHGC	0.276		0.270		0.273		0.269	
% Difference	-2.2%				-1.5%			
Overall VT	0.345		0.346		0.345		0.346	
% Difference	0.29%				0.29%			
U factor C_{cog}	0.320		0.323		0.32		0.323	
% Difference	0.92%				0.92%			
SHGCcog	0.33		0.341		0.33		0.341	
% Difference	3.2%				3.2%			
VTcog	0.44		0.444		0.44		0.444	
% Difference	0.9%				0.9%			
FR	N/A		0.255		N/A		0.444	
% Difference	N/A				N/A			
CI_f	69.11		68.32		76.51		76.13	
CI_g	63.54		64.01		63.54		64.01	
CI_{eog}	50.66		47.46		57.68		55.30	
CI	51		47		58		55	
Difference	-4				-4			

Table 5b1: Simulation Results for the Wood Fixed Window PFM02 w/o the Use of Partially Ventilated Cavities and with Separate Frame Convective Film Coefficient

U factor ($Btu/h\text{-}ft^2\text{-}F$)	Clear-lowE glazing with Al spacer			
	W4_Therm2		W5_Therm5	
	Frame	Edge	Frame	Edge
Head	0.4278	0.4474	0.3899	0.4164
Sill	0.4278	0.4474	0.3927	0.4177
Jamb	0.4278	0.4474	0.3955	0.4179
Overall	0.380		0.365	
% Difference	-4.11%			
Overall SHGC	0.276	0.271		
% Difference	-1.85%			
Overall VT	0.345	0.346		
% Difference	0.29%			
U factor C_{cog}	0.320	0.323		
% Difference	0.92%			
SHGCcog	0.33	0.341		
% Difference	3.2%			
VTcog	0.44	0.444		
% Difference	0.9%			
FR	N/A	0.255		
% Difference	N/A			
CI_f	69.11	68.05		
CI_g	63.54	64.01		
CI_{eog}	50.66	47.39		
CI	51	47		
Difference	-4			

The results from the table 95 have been plotted in Figure 5b. The figure shows the effect of different glazing systems and different spacers on the overall difference percentage.

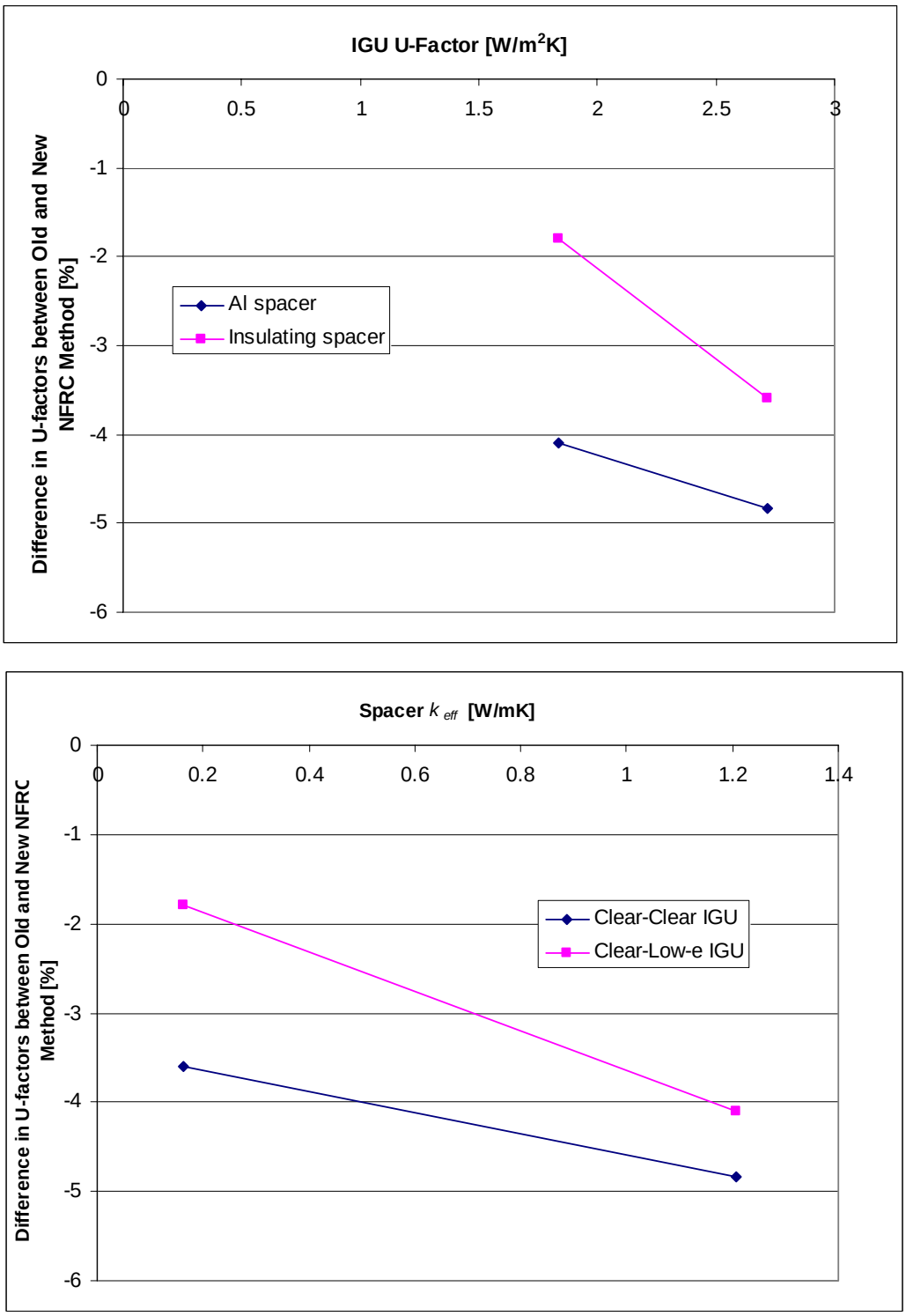

Figure 5b. Effect of glazing system and spacer configuration on relative difference between the old and new NFRC method (excluding size effects)

Case 6: Thermally-Broken Aluminum Curtain Wall with Bolts – 2002 NFRC Simulation Round Robin (SRR02)

This product represent the sample for 2002 NFRC Simulation Round Robin (SRR02). It is a nominal 80’’x80’’ aluminum curtain wall. The schematic representation of the material locations for a sill section is shown in Figure 6. This sample incorporates a bolt, will be modeled as a discontinuous thermal bridging element. The glazing was double-glazed, consisting of nominal 1.0" thick insulating glazing system fabricated from two 0.225" sheets of clear glass, separated by 0.550" air space. Table 6 shows the comparison of results between old NFRC method (WINDOW 4.1 / THERM 2.1a) and new NFRC method (WINDOW 5 / THERM 5).

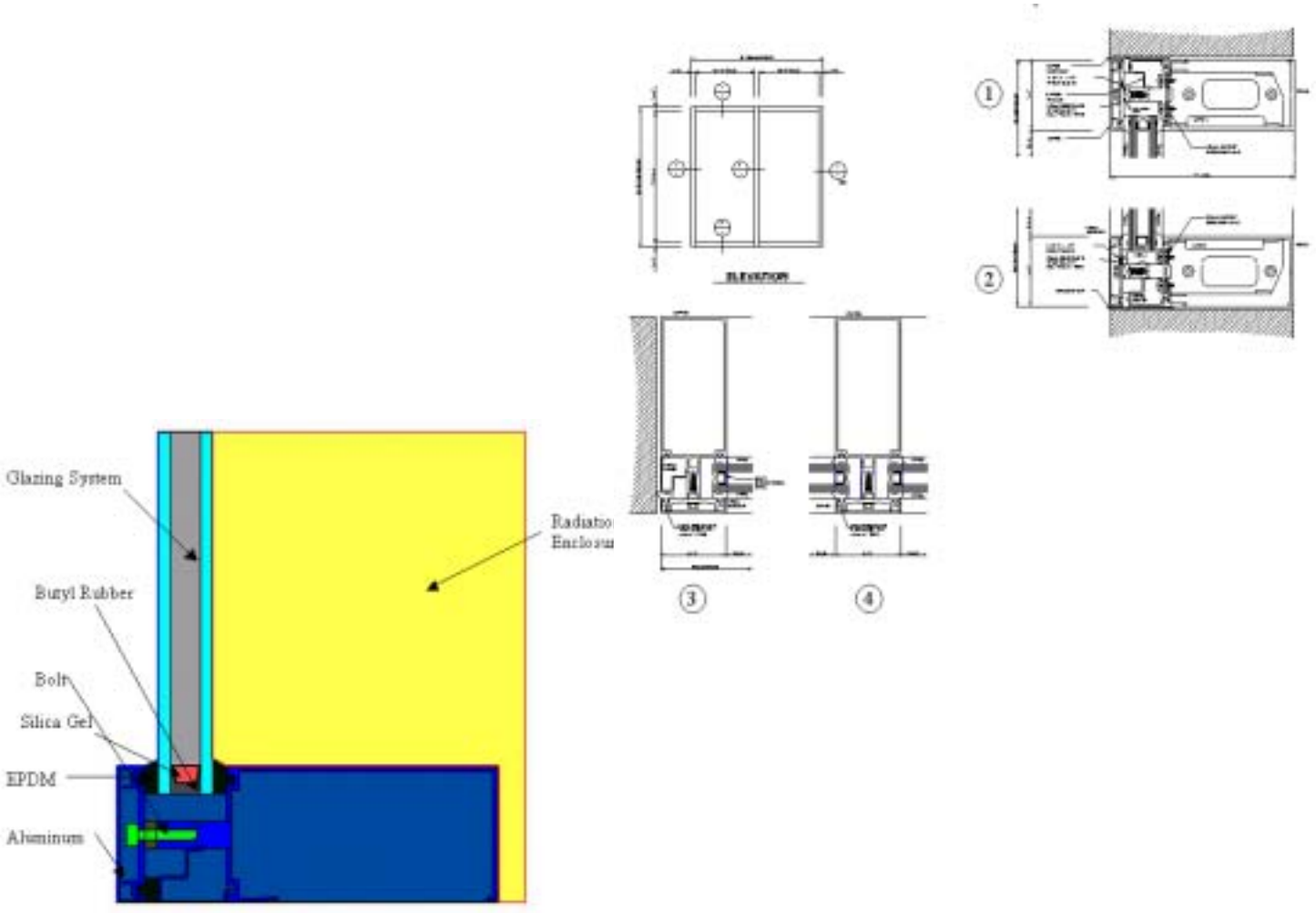

Figure 6. Drawings and List of Materials for a Thermally-Broken Aluminum Curtain Wall with Bolts – 2002 NFRC Simulation Round Robin (SRR02)

Table 6: Simulation Results of Thermally-Broken Aluminum Curtain Wall with Bolts – 2002 NFRC Simulation Round Robin (SRR02)

U factor (Btu/h-ft^2-F)	SRR 02				Experimental
	W4_Therm2		W5_Therm5		
	Frame	Edge	Frame	Edge	
Head	1.0253	0.5293	1.062	0.5043	
Sill	1.0363	0.5299	1.0294	0.5410	
Jamb	1.0727	0.5275	1.0737	0.4934	
Meeting rail	1.3075	0.5139	1.3155	0.4910	
Overall Ufactor	0.589		0.572		
% Difference	-3.00%				
Overall SHGC	0.612		0.606		
% Difference	-1.00%				
Overall VT	0.657		0.659		
% Difference	~				
U factor U_{cog}	0.481		0.470		
% Difference	-2.34%				
$SHGC_{cog}$	0.69		0.702		
% Difference	1.71%				
VT_{cog}	0.78		0.786		
% Difference	~				
FR_{cog}	N/A		0.524		
% Difference	N/A				
CI_f	N/A		47.61		
CI_g	N/A		48.90		
CI_{eog}	N/A		41.02		
CI	N/A		41		
% Difference	N/A				

Case 7: Thermally-Broken (Skip-Pour-De-Bridge) Aluminum Curtain Wall – Example Curtain Wall #1 (CW #1)

This is Aluminum curtain wall with pour and de-bridge type of thermal break, with skipped de-bridged sections (discontinuous thermal break). It is a nominal 80''x80'' unit. The glazing was double-glazed, consisting of nominal 1.0" thick insulating glazing system fabricated from the two 0.225" sheets of glass, and 0.550" air space. The spacer assembly construction is dual seal with Aluminum spacer. The schematic representation and the list of materials (shown for a sill cross section) are shown in Figure 7. Table 7 shows the comparison of results between NFRC 100-97 (WINDOW 4.1/THERM2.1a) and NFRC 100-2002 (WINDOW5/THERM5) models. In addition emissivities of Aluminum surfaces were varied to investigate effects of emissivities on results.

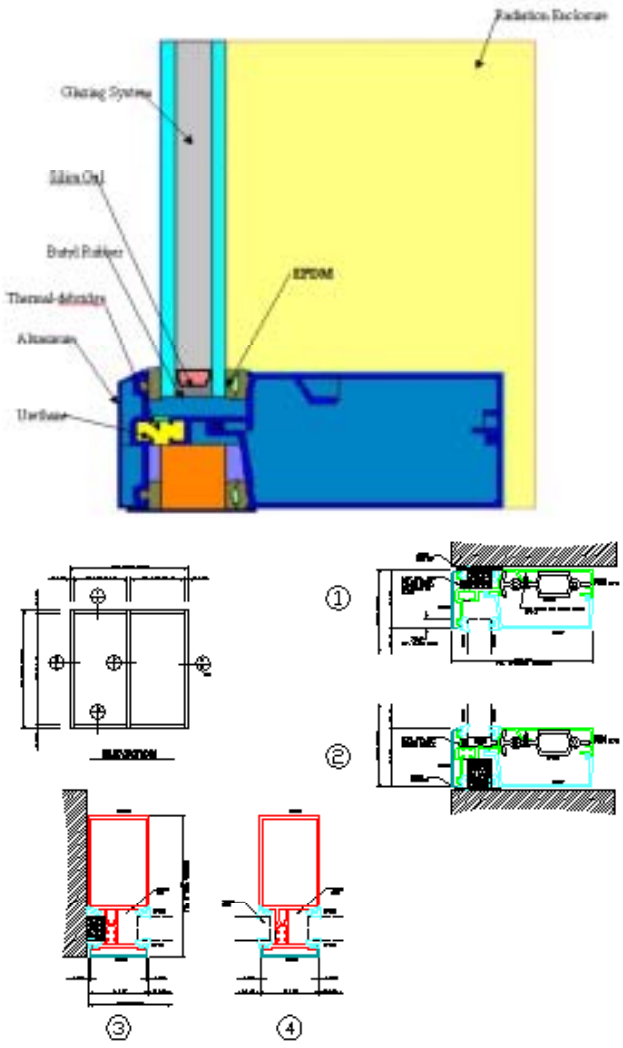

Figure 7. Drawings and List of Materials for a Thermally-Broken Aluminum Curtain Wall with Skip-Pour-De-Bridge Type of Thermal Break – (CW#1)

Table 7: Simulation Results for Thermally-Broken (Skip-Pour-De-Bridge) Aluminum Curtain Wall (CW #1)

U factor ($Btu/h\text{-}ft^2\text{-}F$)	Emissivity =0.9				Emissivity =0.2			
	W4_Therm2		W5_Therm5		W4_Therm2		W5_Therm5	
	Frame	Edge	Frame	Edge	Frame	Edge	Frame	Edge
Head	1.6640	0.4930	1.641	0.467	1.1713	0.5432	1.142	0.517
Sill	1.6722	0.4929	1.672	0.466	1.1889	0.5427	1.161	0.518
Jamb	1.6869	0.4937	1.685	0.470	1.1967	0.5467	1.166	0.520
MR	2.2721	0.4904	2.278	0.466	1.6928	0.5363	1.655	0.511
Overall	0.687		0.667		0.617		0.592	
% Difference	-3.0%				-4.22 %			
Overall SHGC	0.633		0.621 (0.604)*		0.620		0.612 (0.600)*	
% Difference	-1.93% (-4.8%)*				-1.31% (3.33%)*			
Overall VT	0.662		0.664		0.662		0.664	
% Difference	~				~			
U factor U_{cog}	0.481		0.458		0.481		0.458	
% Difference	-5.02 %				-5.02 %			
$SHGC_{cog}$	0.69		0.700		0.69		0.700	
% Difference	1.43 %				1.43 %			
VT_{cog}	0.78		0.786		0.78		0.786	
% Difference	~				~			
FR_{cog}	N/A		0.524		N/A		0.524	
% Difference	N/A				N/A			
CI_f	33.71		32.73		22.43		22.50	
CI_g	51.21		48.90		51.21		48.90	
CI_{eog}	42.06		36.28		49.96		35.78	
CI	34		33		22		22	
Difference	-1				~			

Note: * SHGC calculated using interior tag (interior developed surface area)

Case 8: Thermally-Broken (Skip-Pour-De-Bridge and Thermal Slot) Aluminum Curtain Wall – Example Curtain Wall #3 (CW #3)

This is Aluminum curtain wall with skip-pour-de-bridge thermal break and also thermal slot. It is a nominal 80''x80'' unit. The glazing was double-glazed, consisting of nominal 1.0" thick insulating glazing system fabricated from the two 0.225" sheets of glass, and 0.550" air space. The spacer assembly construction is dual seal with Aluminum spacer. The schematic representation and the list of materials (shown for a meeting rail cross-section) are shown in Figure 8. Table 8 shows the comparison of results between NFRC 100-97 (WINDOW 4.1/THERM2.1a) and NFRC 100-2002 (WINDOW5/THERM5) models. In addition emissivities of Aluminum surfaces were varied to investigate effects of emissivities on results.

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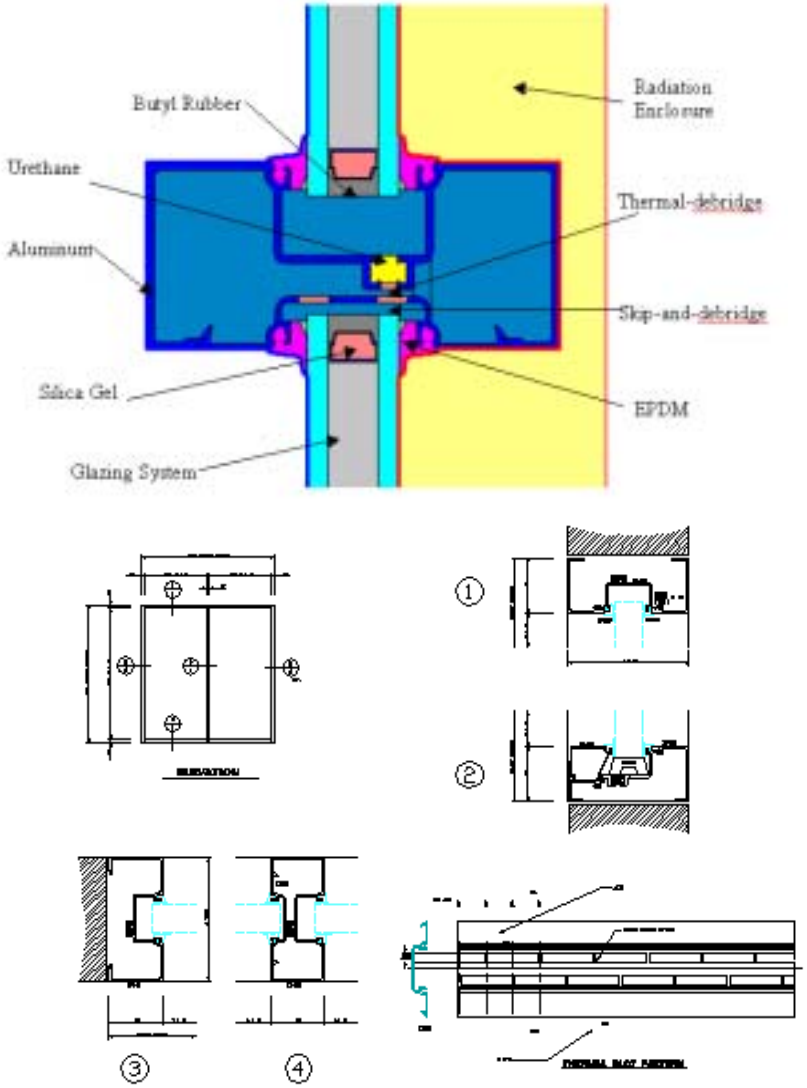

Figure 8. Drawings and List of Materials for a Thermally-Broken Aluminum Curtain Wall with Skip-Pour-De-Bridge Type of Thermal Break and Thermal Slot – (CW#3)

Table 8: Simulation Results for Thermally-Broken (Skip-Pour-De-Bridge and Thermal Slot) Aluminum Curtain Wall – Example Curtain Wall #3 (CW #3)

U factor ($Btu/h\text{-}ft^2\text{-}F$)	Emissivity =0.9				Emissivity =0.2			
	W4_Therm2		W5_Therm5		W4_Therm2		W5_Therm5	
	Frame	Edge	Frame	Edge	Frame	Edge	Frame	Edge
Head	1.3439	0.5307	1.3262	0.5066	0.9258	0.5665	0.9109	0.5414
Sill	1.3378	0.5277	1.3213	0.5044	0.9199	0.5637	0.9062	0.5393
Jamb	1.3430	0.5306	1.3285	0.5070	0.9253	0.5664	0.9097	0.5418
MR	1.7201	0.5299	1.7141	0.5077	1.2367	0.5650	1.2224	0.5399
Overall	0.622		0.600		0.567		0.545	
% Difference	-4.01 %				-4.04 %			
Overall SHGC	0.630		0.616		0.620		0.612	
% Difference	-2.27 %				-1.31 %			
Overall VT	0.674		0.676		0.674		0.676	
% Difference	0.89 %				0.89 %			
U factor U_{cog}	0.481		0.470		0.481		0.470	
% Difference	-2.34 %				-2.34 %			
$SHGC_{cog}$	0.690		0.702		0.690		0.702	
% Difference	1.71 %				1.71 %			
VT_{cog}	0.780		0.786		0.780		0.786	
% Difference	0.76 %				0.76 %			
FR_{cog}	N/A		0.524		N/A		0.524	
% Difference	N/A				N/A			
CI_f	21.07		21.46		14.87		14.88	
CI_g	48.90		48.90		48.90		48.90	
CI_{eog}	35.89		36.04		35.60		35.64	
CI	21		21		15		15	
% Difference	~				~			

Table 8a: Simulation Results for Thermally-Broken (Skip-Pour-De-Bridge and Thermal Slot) Aluminum Curtain Wall – Example Curtain Wall #3 (CW #3) w/o the Use of Partially Ventilated Cavities and with Separate Frame Convective Film Coefficient

U factor ($Btu/h\text{-}ft^2\text{-}F$)	Emissivity =0.9				Emissivity =0.2			
	W4_Therm2		W5_Therm5		W4_Therm2		W5_Therm5	
	Frame	Edge	Frame	Edge	Frame	Edge	Frame	Edge
Head	1.3439	0.5307	1.3262	0.5066	0.9258	0.5665	0.9415	0.5389
Sill	1.3378	0.5277	1.3213	0.5044	0.9199	0.5637	0.9368	0.5374
Jamb	1.3430	0.5306	1.3285	0.5070	0.9253	0.5664	0.9405	0.5398
MR	1.7201	0.5299	1.7141	0.5077	1.2367	0.5650	1.2642	0.5387
Overall	0.622		0.600		0.567		0.543	
% Difference	-4.01 %				-4.42%			
Overall SHGC	0.630		0.616		0.620		0.600	
% Difference	-2.27 %				-3.33%			
Overall VT	0.674		0.676		0.674		0.667	
% Difference	0.89 %				-1.05%			
U factor U_{cog}	0.481		0.470		0.481		0.470	
% Difference	-2.34 %				-2.34 %			
$SHGC_{cog}$	0.690		0.702		0.690		0.702	
% Difference	1.71 %				1.71 %			
VT_{cog}	0.780		0.786		0.780		0.786	
% Difference	0.76 %				0.76 %			
FR_{cog}	N/A		0.524		N/A		0.524	
% Difference	N/A				N/A			
CI_f	21.07		21.46		14.87		15.36	
CI_g	48.90		48.90		48.90		48.90	
CI_{eog}	35.89		36.04		35.60		35.81	
CI	21		21		15		15	
% Difference	~				~			

Case 9: Thermally-Improved Aluminum Curtain Wall – Example Curtain Wall #4 (CW#4)

This is Aluminum curtain wall with thermal improvement in the form of a frame clip, made of thermal break material and being non-continuous. Like other curtain wall units, it is a nominal 80''x80'' unit. The glazing was double-glazed, consisting of nominal 1.0" thick insulating glazing system fabricated from the two 0.225" sheets of glass, and 0.550" air space. The spacer assembly construction is dual seal with Aluminum spacer. The schematic representation and the list of materials (shown for a meeting rail cross-section) are shown in Figure 9. Table 9 shows the comparison of results between NFRC 100-97 (WINDOW 4.1/THERM2.1a) and NFRC 100-2002 (WINDOW5/THERM5) models. In addition emissivities of Aluminum surfaces were varied to investigate effects of emissivities on results.

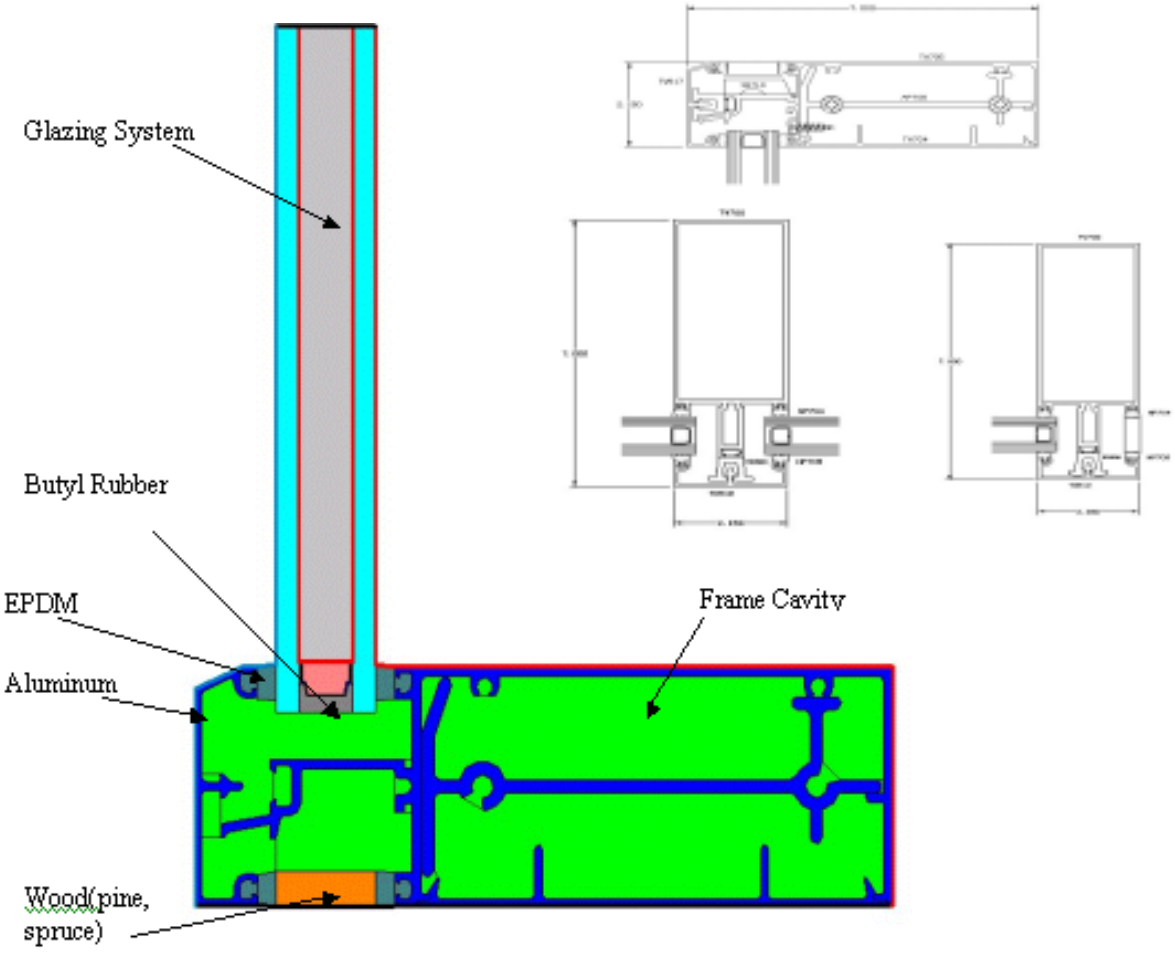

Figure 9. Drawings and List of Materials for a Thermally-Improved Aluminum Curtain Wall with Discontinuous Thermal Break – (CW#4)

Table 9: Simulation Results for Thermally-Improved Aluminum Curtain Wall – Example Curtain Wall #4 (CW#4)

U factor ($Btu/h\text{-}ft^2\text{-}F$)	Emissivity =0.9				Emissivity =0.2			
	W4_Therm2		W5_Therm5		W4_Therm2		W5_Therm5	
	Frame	Edge	Frame	Edge	Frame	Edge	Frame	Edge
Head	1.3458	0.4797	1.2188	0.4658	1.0510	0.5259	0.9256	0.5006
Sill	1.3717	0.4736	1.2210	0.4556	1.0603	0.5225	0.9614	0.5296
Jamb	1.2808	0.4748	1.0795	0.4582	1.0040	0.5193	0.8572	0.4923
MR	1.7493	0.4724	1.7542	0.4930	1.4294	0.5086	1.3658	0.5168
Overall	0.606		0.571		0.573		0.539	
% Difference	-6.1%				-6.3%			
Overall SHGC	0.632		0.623		0.625		0.618	
% Difference	-1.4%				-1.1%			
Overall VT	0.677		0.679		0.677		0.679	
% Difference	0.29%				0.29%			
U factor U_{cog}	0.481		0.470		0.481		0.470	
% Difference	-52.3%				-2.3%			
$SHGC_{cog}$	0.69		0.702		0.69		0.702	
% Difference	1.7%				1.7%			
VT_{cog}	0.78		0.786		0.78		0.786	
% Difference	0.8%				0.8%			
FR_{cog}	N/A		0.524		N/A		0.524	
% Difference	N/A				N/A			
CI_f			57.85				45.80	
CI_g			48.90				48.90	
CI_{eog}			43.23				42.08	
CI			43				42	
Difference								

Case 10: Thermally Broken Aluminum Skylight

This is 24”x48” thermally broken Aluminum skylight with wood curb. The schematic representation of geometry and materials is shown in Figure 10. The glazing unit consists of two panes of 0.129" sheets of PPG glass, one clear and the other with low-e coating, with the emissivity of 0.096 at surface 3. The cavity of 0.75” is filled with the mixture of Air (10%), and Argon (90%). As per new NFRC calculation procedure, the calculations with WINDOW5 and THERM 5 have been performed at 20^{o} tilt. Table 10 shows the comparison of results between the old and new NFRC method.

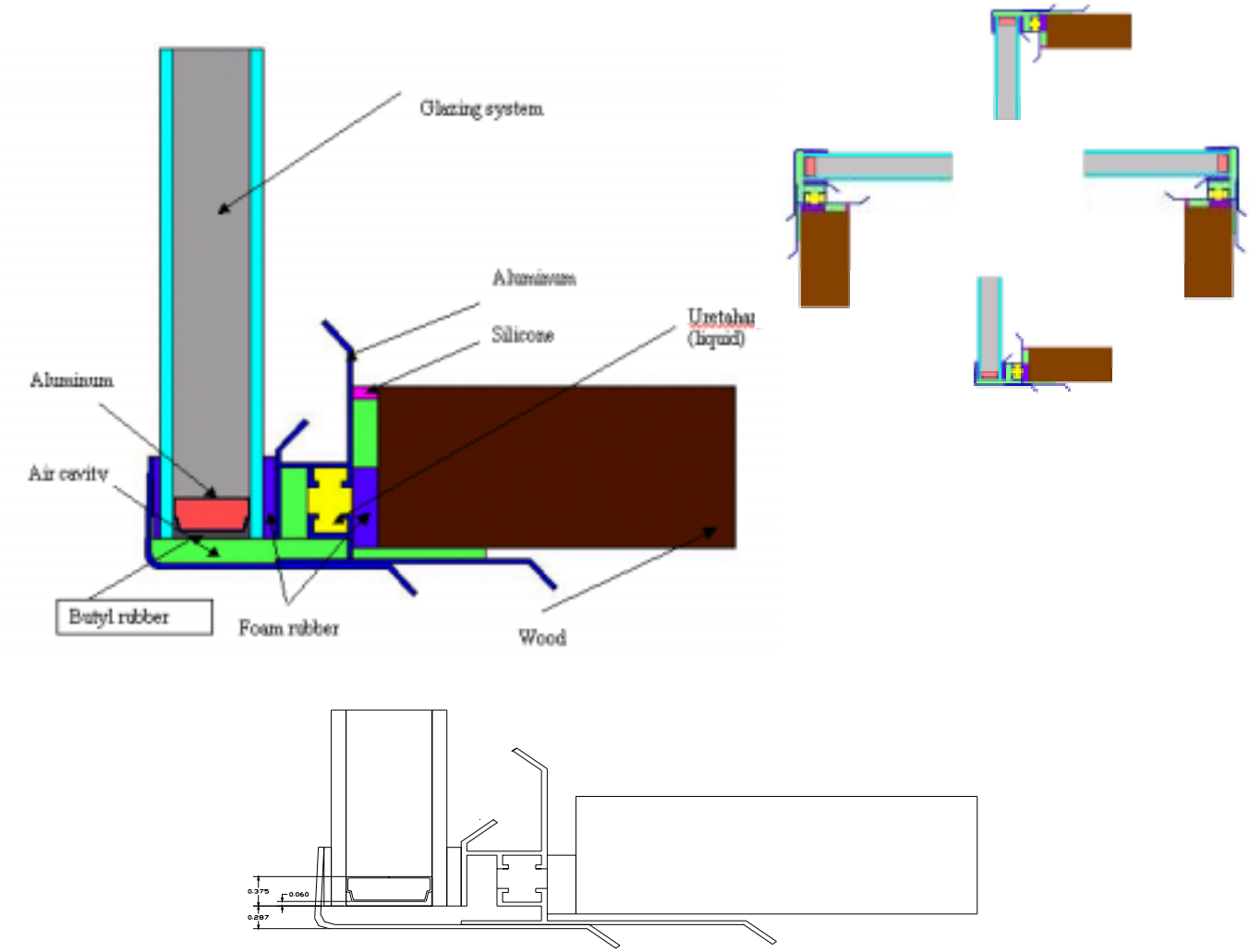

Figure 10. Drawings and List of Materials for a Thermally-Broken Aluminum Skylight

Table 10: Simulation Results of thermally-broken skylight with high performance IGU

U factor ($Btu/h\text{-}ft^2\text{-}F$)	Clear-lowE Argon IGU w/ Al spacer				Clear-lowE Argon IGU w/ super spacer			
	W4_Therm2		W5_Therm5		W4_Therm2		W5_Therm5	
	Frame	Edge	Frame	Edge	Frame	Edge	Frame	Edge
Head	5.3511	0.3032	5.5881	0.3662	5.1841	0.2917	5.4579	0.3618
Sill	5.2998	0.3027	5.5652	0.3647	5.1762	0.2982	5.4464	0.3618
Jamb	2.2998	0.3027	5.5844	0.3645	5.1762	0.2982	5.4163	0.3612
Overall	0.669		0.758		0.657		0.745	
% Difference	11.74%				11.81%			
Overall SHGC	0.624		0.573		0.622		0.572	
% Difference	-9.28%				-8.74%			
Overall VT	0.689		.690		0.689		0.690	
% Difference	~				~			
U factor C_{cog}	0.283		0.362		0.283		0.362	
% Difference	21.82%				21.82%			
SHGCcog	0.60		0.615		0.600		0.615	
% Difference	2.44%				2.44%			
VTcog	0.75		0.746		0.750		0.746	
% Difference	~				~			
FR	N/A		0.473		N/A		0.473	
% Difference	N/A				N/A			
CI_f	N/A		38.18		N/A		39.90	
CI_g	N/A		63.68		N/A		63.68	
CI_{eog}	N/A		52.51		N/A		53.03	
CI	N/A		38		N/A		40	
% Difference	N/A				N/A			

Table 10a: **Simulation Results of thermally-broken skylight with high performance IGU w/o the Use of Partially Ventilated Cavities and with Separate Frame Convective Film Coefficient**

U factor ($Btu/h\text{-}ft^2\text{-}F$)	Clear-lowE Argon IGU w/ Al spacer			
	W4_Therm2		W5_Therm5	
	Frame	Edge	Frame	Edge
Head	5.3511	0.3032	6.064	0.359
Sill	5.2998	0.3027	6.069	0.3660
Jamb	2.2998	0.3027	6.213	0.362
Overall	0.669		0.801	
% Difference	16.48%			
Overall SHGC	0.624	0.571		
% Difference	-9.28%			
Overall VT	0.689	.690		
% Difference	0.14			
U factor C_{cog}	0.283	0.362		
% Difference	21.82%			
SHGCcog	0.60	0.615		
% Difference	2.44%			
VTcog	0.75	0.746		
% Difference	~			
FR	N/A	0.473		
% Difference	N/A			
CI_f	N/A	38.18		
CI_g	N/A	63.68		
CI_{eog}	N/A	52.51		
CI	N/A	38		
% Difference	N/A			

Table 10b: Simulation Results for thermally broken skylight for low performance IGU

U factor ($Btu/h\text{-}ft^2\text{-}F$)	Clear-clear glazing with Al spacer				Clear-clear glazing with super spacer			
	W4_Therm2		W5_Therm5*		W4_Therm2		W5_Therm5*	
	Frame	Edge	Frame	Edge	Frame	Edge	Frame	Edge
Head	5.4516	0.4788	5.9775	0.5459	5.3652	0.4869	5.9180	0.5440
Sill	5.4167	0.4888	5.9631	0.5457	5.3617	0.4869	5.8678	0.5442
Jamb	5.4167	0.4888	5.9338	0.5457	5.3617	0.4869	5.9282	0.5437
Overall	0.865		0.966		0.860		0.964	
% Difference	10.53%				10.79%			
Overall SHGC	0.766		0.704		0.765		0.704	
% Difference	-8.81%				-8.67%			
Overall VT	0.751		0.752		0.751		0.752	
% Difference	~				~			
U factor U_{cog}	0.493		0.564		0.493		0.564	
% Difference	12.59%				12.59%			
SHGCcog	0.750		0.757		0.750		0.757	
% Difference	~				0.92%			
VTcog	0.810		0.813		0.810		0.813	
% Difference	~				~			
FR	N/A		.612		N/A		0.612	
% Difference	N/A				N/A			
CI_f	N/A		38.88		N/A		38.58	
CI_g	N/A		46.79		N/A		46.79	
CI_{eog}	N/A		41.43		N/A		41.61	
CI	N/A		38		N/A		39	
%Difference	N/A				N/A			

* W5 calculations have been carried out at 20^o tilt

Case 11: Aluminum-Clad Wood Skylight

The skylight is 36”x60” Aluminum-clad wood frame. The schematic representation of the material locations for a sill section is shown in Figure 11. The glazing unit consists of two panes of 0.118" sheets of low-e (e_2=0.03) and clear Cardinal IG glass. The cavity width is 0.428” and is filled with Air. As per new calculation procedure, the calculations with WINDOW5 have been performed at 20^o tilt. Table 11 shows the comparison of results between NFRC 100-97 (WINDOW 4.1/THERM2.1a) and NFRC 100-2002 (WINDOW5/THERM5) models.

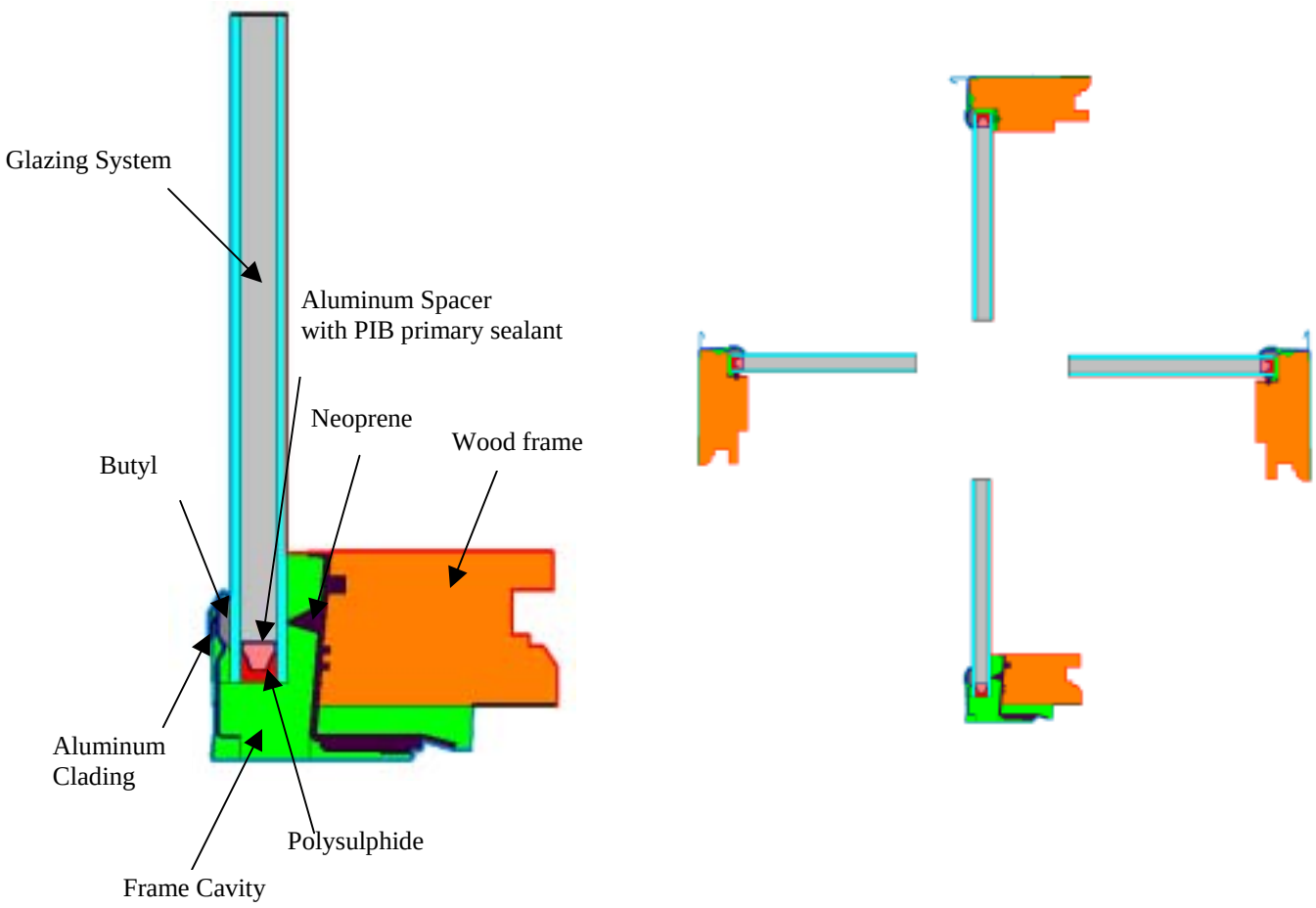

Figure 11. Drawings and List of Materials for a Aluminum-Clad Wood Skylight

Table 11a: Simulation Results for Aluminum-Clad Wood Skylight (Air filling)

U-factor	W4_Therm2		W5_Therm5*	
	Frame	Edge	Frame	Edge
Head	0.8253	0.4233	0.8456	0.5151
Sill	0.9075	0.3419	0.7473	0.4493
Jamb	0.8253	0.4233	0.8767	0.5133
Overall U	0.400		0.501	
% Difference	19.95%			
Overall SHGC	0.338		0.322	
% Difference	-4.64%			
Overall VT	0.597		0.597	
% Difference	~			
U factor U_{cog}	0.3037		0.4218	
% Difference	27.99%			
$SHGC_{cog}$	0.37		0.37	
% Difference	~			
VT_{cog}	0.70		0.70	
% Difference	~			
FR_{cog}	N/A		0.3146	
% Difference	N/A			
CI_f	N/A		60.92	
CI_g	N/A		57.60	
CI_{eog}	N/A		42.33	
CI	N/A		42	
% Difference	N/A			

* W5 calculations have been carried out at 20^o tilt

Table 11a1: Simulation Results for Aluminum-Clad Wood Skylight (Air filling) w/o the Use of Partially Ventilated Cavities and with Separate Frame Convective Film Coefficient

U-factor	W4_Therm2		W5_Therm5*	
	Frame	Edge	Frame	Edge
Head	0.8253	0.4233	0.841	0.515
Sill	0.9075	0.3419	0.743	0.449
Jamb	0.8253	0.4233	0.872	0.513
Overall U	0.400		0.500	
% Difference	20.0%			
Overall SHGC	0.338		0.320	
% Difference	-5.62%			
Overall VT	0.597		0.597	
% Difference	~			
U factor U_{cog}	0.3037		0.4218	
% Difference	27.99%			
$SHGC_{cog}$	0.37		0.37	
% Difference	~			
VT_{cog}	0.70		0.70	
% Difference	~			
FR_{cog}	N/A		0.3146	
% Difference	N/A			
CI_f	N/A		60.92	
CI_g	N/A		57.60	
CI_{eog}	N/A		42.33	
CI	N/A		42	
% Difference	N/A			

* W5 calculations have been carried out at 20^o tilt

Table 11b. Simulation Results for Aluminum-Clad Wood Skylight (Argon filling)

U-factor	W4_Therm2		W5_Therm5*	
	Frame	Edge	Frame	Edge
Head	0.8188	0.3856	0.8416	0.4645
Sill	0.9030	0.2973	0.7370	0.3944
Jamb	0.8188	0.3856	0.8690	0.4642
Overall U	0.360		0.4477	
% Difference	19.52%			
Overall SHGC	0.336		0.3194	
% Difference	-5.20%			
Overall VT	0.597		0.5975	
% Difference	~			
U factor U_{cog}	0.2498		0.3574	
% Difference	30.11%			
$SHGC_{cog}$	0.37		0.37	
% Difference	~			
VT_{cog}	0.70		0.70	
% Difference	~			
FR_{cog}	N/A		0.31	
% Difference	N/A			
CI_f	N/A		60.88	
CI_g	N/A		63.94	
CI_{eog}	N/A		45.10	
CI	N/A		45	
% Difference	N/A			

* W5 calculations have been carried out at20^o tilt

Appendix: Thermal conductivity of materials used for simulation

Material	*k* (Btu/h-ft-F)
Aluminum	92.44
Polyurethane	0.017
Urethane(liquid)	0.179
Glass-clear	0.270
Silica Gel	0.017
Butyl Rubber	0.138
PIB	0.138
Bolt*	0.47
Neoprene	0.109
EPDM	0.144
Skip-and-debridge*	8.7028
Thermal-debridge*	9.7469

* calculated k_{eff}